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Stabilization of linear systems
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The core of the book are the two chapters on stabilization of systems with two time scales, and on high-gain output feedback stabilization of minimum-phase systems. This takes a third out of 300 pages. On the one hand, these topics make the book distinct from the variety of existing textbooks on stabilization of linear systems; on the other hand, these issues are treated in much more detail than in the standard research monograph on 'Singular perturbation methods in control' by Kokotovič, Khalil, and O'Reilly (1986).

Systems with two time scales and high-gain stabilization are treated in Chapters 3 and 4. In the preceding Chapter 2 various general results on stabilization of linear systems are proved, and the core Chapters 3 and 4 are followed by two more specific chapters on adaptive stabilization and on its discrete implementations using holds. This makes the whole book self-contained, and it can be easily studied by undergraduates being familiar with the fundamentals of ordinary differential equations and linear algebra, systems theory is not required. The style and mathematical rigour is rather addressed to mathematicians than to engineers. But a proof of high-gain feedback stabilization of higher relative degree systems requires the Popov form, which unavoidably requires a technically involved presentation with pages full of matrix equations. However, the feedback laws are simple, and this is an appealing feature of minimum-phase systems. As the authors stress "this book is not intended to be a textbook nor a guide for control designers". But it gives a deeper mathematical insight into a class of systems which is relevant for many engineering applications. Each chapter is finalized with a section on notes and references, which is quite useful for further reading.

In the remainder of this review, I give a more detailed description of the contents. The book is divided into six chapters and they include the following.

The Introduction is essentially a brief motivation on stabilization of systems with two time scales.

In the 70 pages of Chapter 2, the reader finds a nice compilation of well-known general results (including the proofs) on stabilization of linear systems (such as stabilizability, optimal stabilization, estimators, disturbance attenuation).

As mentioned above, Chapters 3 and 4 are the core of the book. In Chapter 3, many of the general results in Chapter 2 are proved for two time-scale systems, provided the suitable assumptions are made. The structure of these systems is studied in detail to obtain sharp bounds on the evolution of the closed-loop system when feedback is applied, for example by using state estimates. (Sub-)optimal stabilization is investigated, too.

Chapter 4 is on high-gain output feedback stabilization of multivariable minimum-phase systems. Certainly, due to the high-gain feedback, the closed-loop system can be considered as a system with two time scales so that this fits nicely with preceding results. Stabilization with output feedback including its derivatives is also proved for higher relative degree systems with generalized invertible high-frequency gain. Interesting are the results on perfect regulation, that means the state of the closed-loop system tends to zero and, the larger the gain, the smaller the overshoot of the output.

Chapter 5 treats the natural question how to stabilize systems considered in previous chapters adaptively if the entries of these systems are unknown but only structural information is available. This structural information is essential minimum-phase and a condition on the generalized high-frequency gain. The high gain becomes a time-varying matrix depending on the output and the knowledge of the high-frequency gain matrix. The results are extended to relative degree two systems and systems with two time scales, and an application to adaptive identification is presented.

Chapter 6 deals with another natural question, namely whether some of the feedback laws in Chapters 3 and 4 still work if the state or the output is only available at discrete points and has to be fed into the system using a hold. The qualitative and quantitative consequences of these modified feedback laws are again treated in detail and with great care.

My guess is that the book by Drăgan and Halanay will become a standard reference for linear two scale systems and output feedback of minimum-phase systems.

References

Kokotovič, P., Khalil, H. K., & O'Reilly, J. (1986). *Singular perturbation methods in control: Analysis and design*. London: Academic Press.

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Achim Ilchmann was born in Düsseldorf, FRG, in 1956. He received the diploma degree from the University of Oldenburg in 1983, the Ph.D. from the University of Bremen in 1987, and the Habilitation from the University of Hamburg in 1993, all in Mathematics. From 1987 to 1994 he was a Hochschulassistent (Associate Professor) at the University of Hamburg, apart from 1990 to 1992 which he spent as a Research Fellow at the University of Exeter, UK. From 1994 to 1996 he was a temporary Professor at the Medical University of Lübeck, FRG, and from 1996 to 2000, a Lecturer, later a Reader, in Applied

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